

ADVANCED COOLING STRATEGIES/TECHNOLOGIES: Closed-Loop (Wet Surface) Evaporative Cooling Systems for Steam Condensing and Aux Loop Cooling in Water Limited Power Plants

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WSAC APPLICATIONS in the **POWER INDUSTRY**



WSAC Applications in the **Power Industry**

- Simple Cycle Auxiliary Loop Water Cooling
- Combined Cycle Auxiliary Loop Water Cooling
- Vacuum Steam Condensing
- Gas Turbine Inlet Air Cooling System Condensers
- As a First-Stage Evaporator in Zero Discharge Plants
- De-Bottlenecking of “Thermally Challenged” Plants

The Wet Surface Air Cooler (WSAC) is a Closed-Loop, Evaporative Cooling System

- Open Loop Water Never Contaminates the Closed Loop System
- Thermal Performance is Maintained
- Poor Quality Water can be Used as Makeup Source
- Higher Cycles of Concentration
- Less Site Water and Blowdown

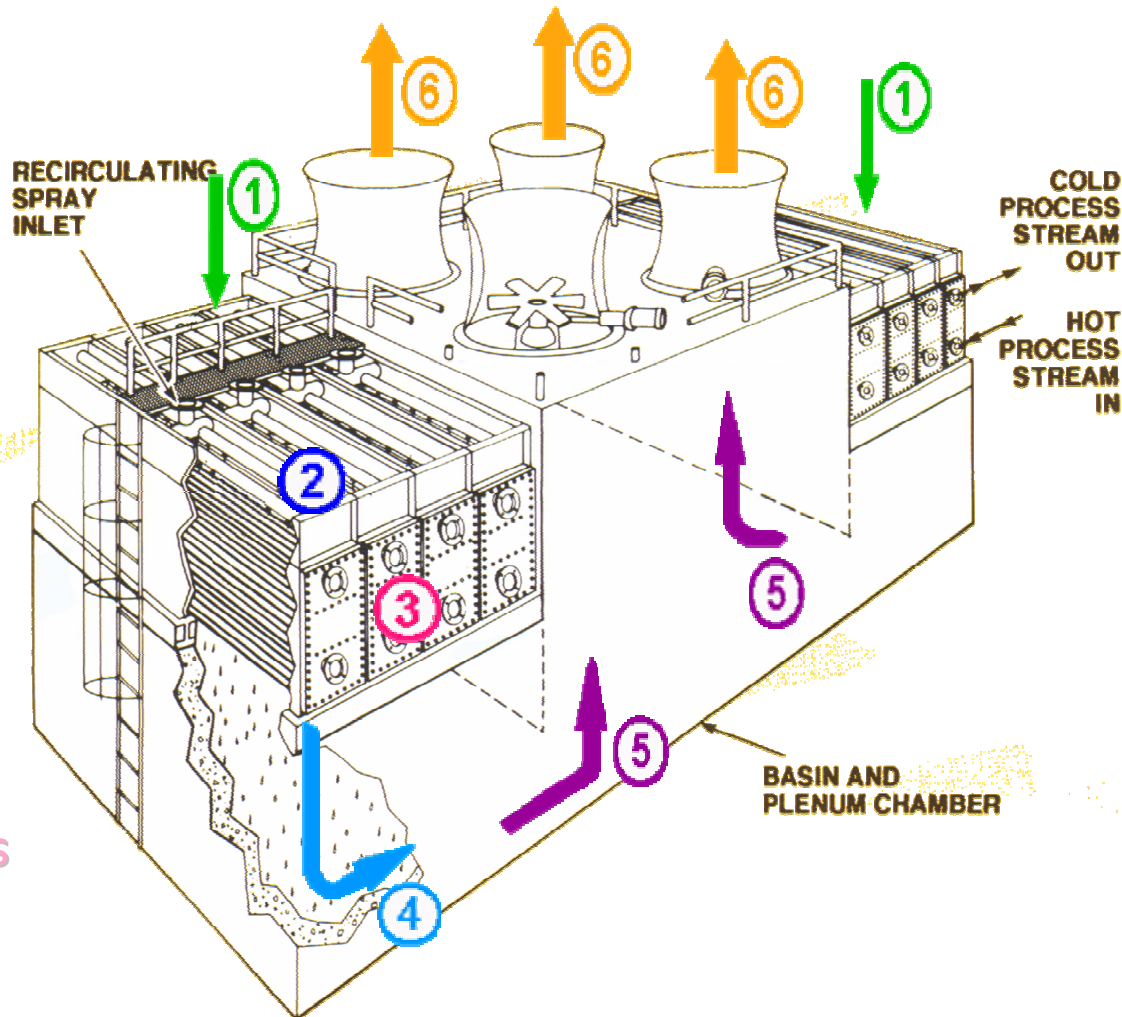
WSAC IS A WATER-CONSERVING SYSTEM

How Does the WSAC Work?

★ Air is induced downward over tube bundles

★ Water flows downward along with the air

★ Heat from the process stream is released to the cascading water

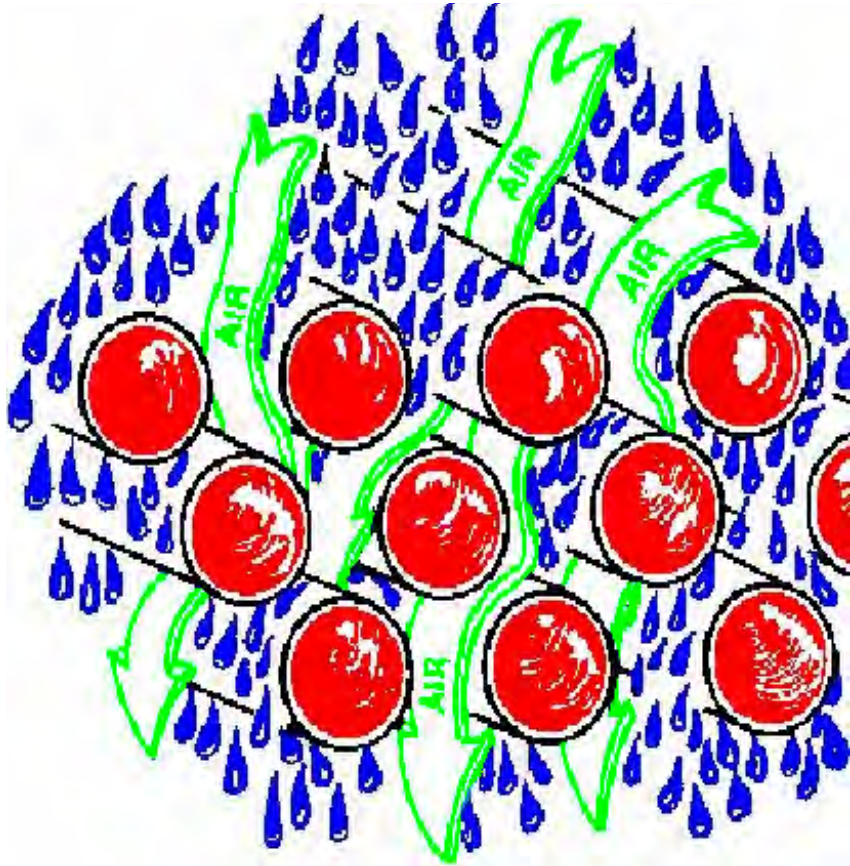


★ Heat is transferred from the cascading water to the air stream via vaporization

✚ Air stream forced to turn 180° providing maximum free water removal

✚ Fans discharge air vertically at a high velocity preventing recirculation

How Does the WSAC Work?



Process fluid flows through tubes

Spray water drenches tubes

Air is induced over spray water and tubes

Heat is removed through the evaporative effect of the spray water



WSAC

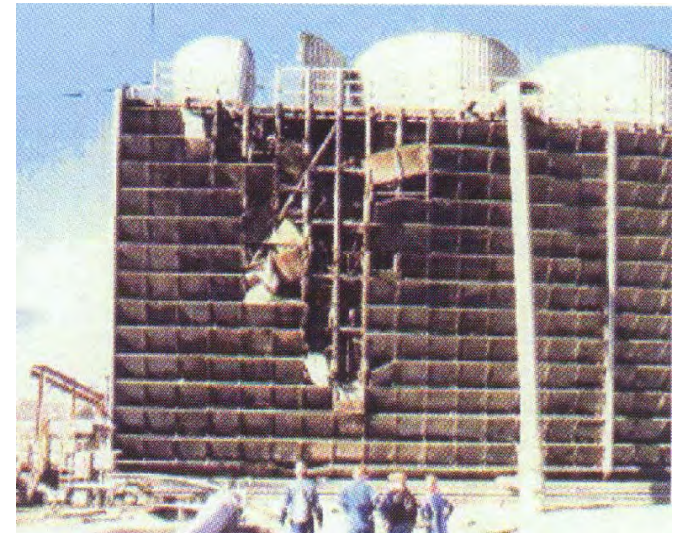
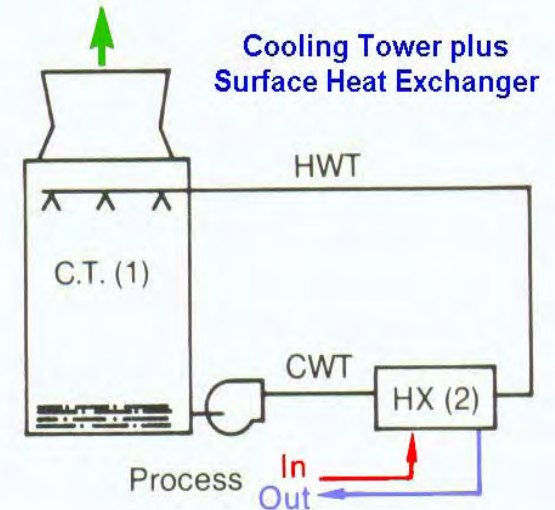
REPLACES

Cooling Tower
+
Heat Exchanger *or* **Air Cooled**
+ **Heat Exchanger**
Pumps & Piping
Loop

Competing Technologies

•Design Conditions: 95°F DB 75°F WB

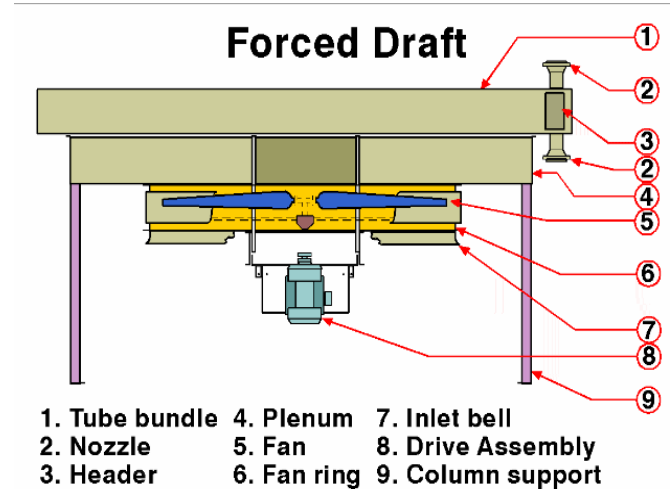
Thermal System	Two Stage (Latent/Sensible)
Practical Approach Temp.	(1) CWT approach to WB...10°F (2) CPT approach to CWT...5°F
Coldest Practical Final Process Temp. (CPT)	90°F
Thermal System Responsibility	Divided between Cooling Tower and Heat Exchanger
Process Side Access for Cleaning	Available but requires special consideration since cooling tower water should also be accessible
Retubability in Place	Available
Water Treatment	HX allows for only 4-6 cycles of concentration (High blowdown rate)



Competing Technologies

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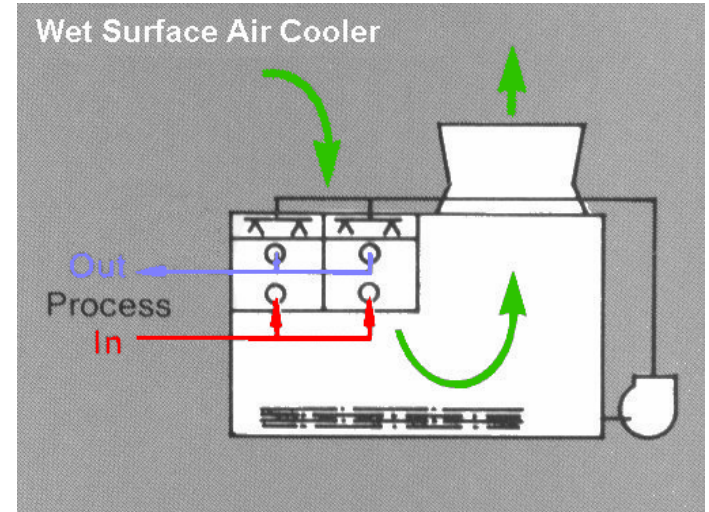
Thermal System	One Stage (Sensible)
Practical Approach Temp.	CPT approach to DB...25°F
Coldest Practical Final Process Temp. (CPT)	120°F
Thermal System Responsibility	Single Source
Process Side Access for Cleaning	Full Mechanical accessibility if removable headers exist
Retubability in Place	Not Normally Available
Water Treatment	None required Close fin spacing (8 or more fin/inch) requires frequent air side cleaning in most industrial atmospheres



WSAC Technology

•Design Conditions: 95°F DB 75°F WB

Thermal System	One Stage (Latent)
Practical Approach Temp.	Cpt approach to WB...10°F
Coldest Practical Final Process Temp. (CPT)	85°F
Thermal System Responsibility	Single Source
Process Side Access for Cleaning	Full Mechanical accessibility
Retubability in Place	Standard Practice
Water Treatment	Able to run high cycles of concentration



Advantages of Using the WSAC for Simple and Combined Cycle Aux Loop Cooling

- Lower First (Installed) Cost
- Cooler Fluid Temperature to Turbine and Generator
- Less Parasitic Energy Required
- Lower Operating and Maintenance Costs
- Fireproof Construction
- Freeze Protected

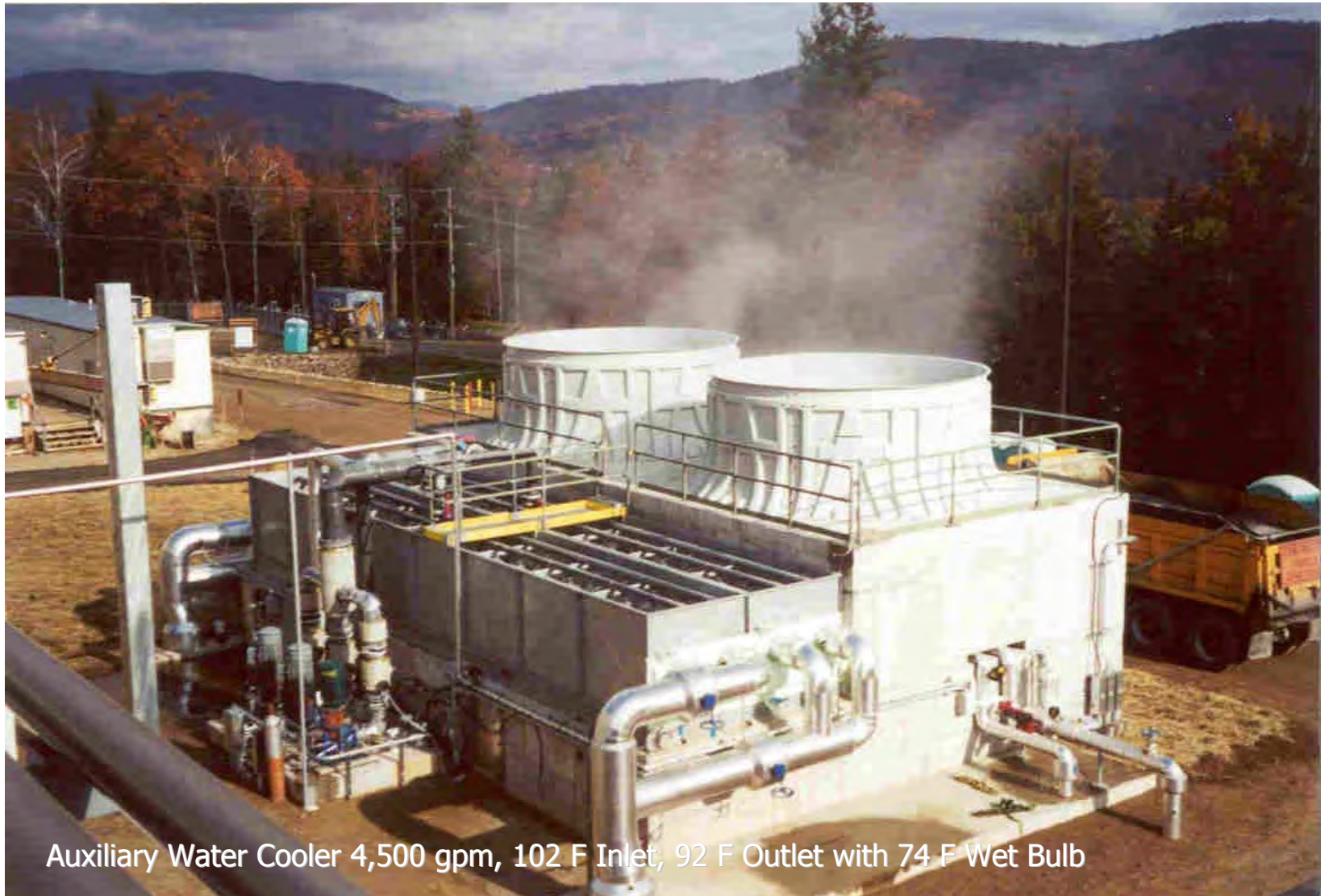
Simple Cycle Aux Loop Cooler for 50 MW Turbines



Simple Cycle Aux Loop Cooler for 187 MW Turbines



Combined Cycle Aux Loop Fluid Cooler

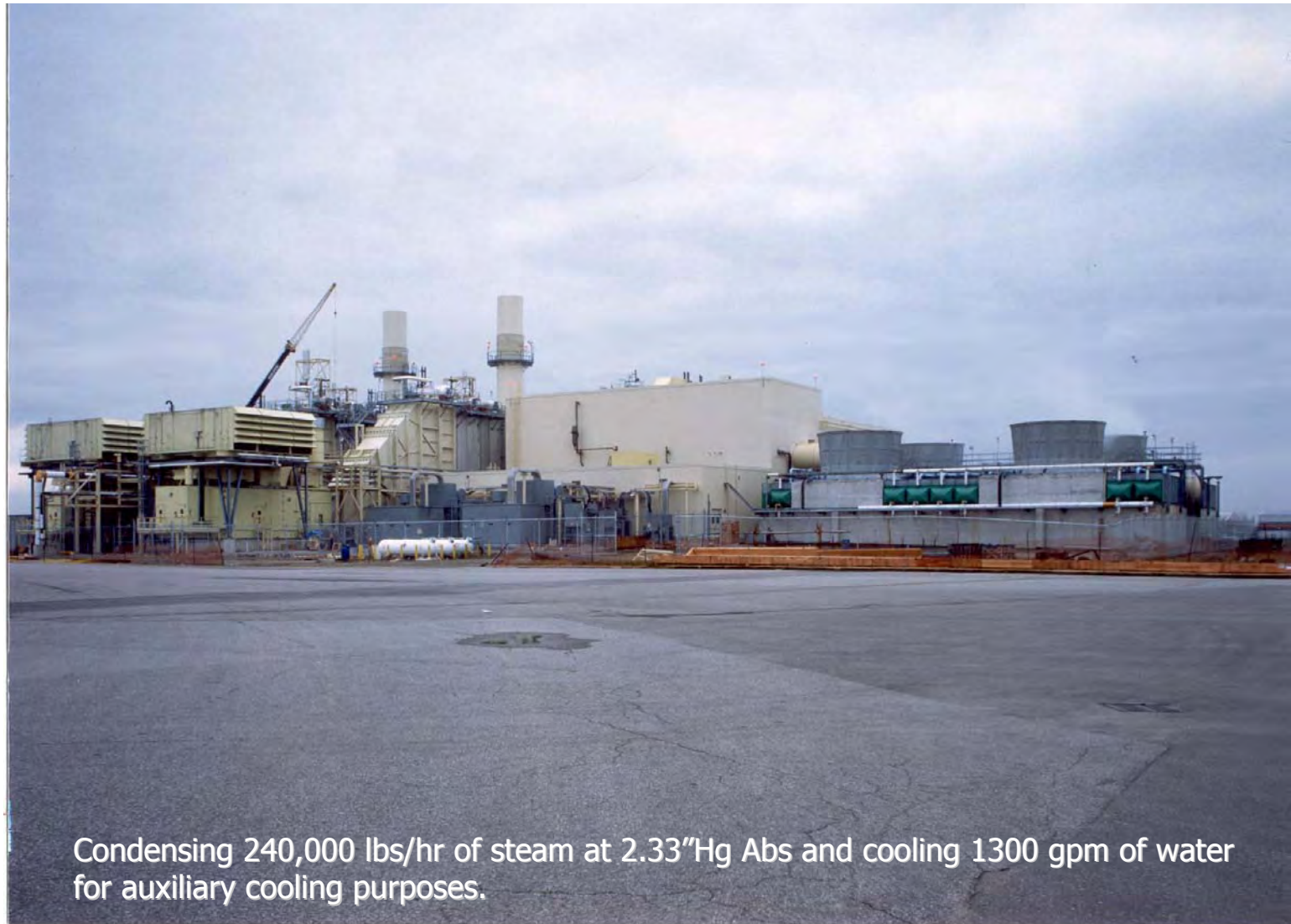


Auxiliary Water Cooler 4,500 gpm, 102 F Inlet, 92 F Outlet with 74 F Wet Bulb

Advantages of Using the WSAC for Combined Cycle Steam Condensing

- Single Source Thermal Responsibility
- Lower Steam Condensing Temperature / Pressure
- Less Parasitic Energy Required
- Lower Operating and Maintenance Costs
- Fireproof Construction
- Freeze Protected

Steam Condensing



Condensing 240,000 lbs/hr of steam at 2.33"Hg Abs and cooling 1300 gpm of water for auxiliary cooling purposes.

Steam Condensing



670,000 LB/HR STEAM CONDENSING
8,100 GPM AUX LOOP COOLING

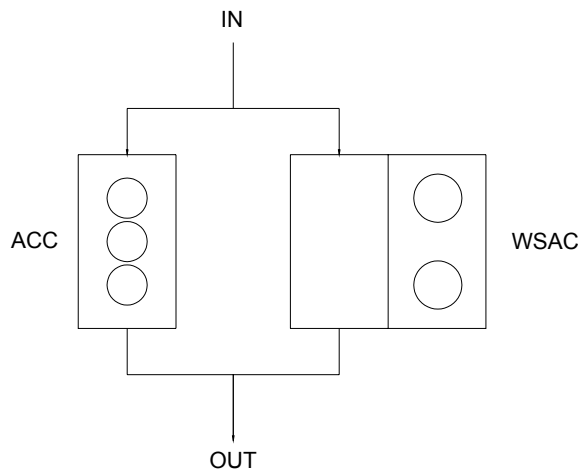
WET / DRY Aux Loop Coolers and Steam Condensers

A Cooling/Condensing Unit that Offers the Combined Advantages of:

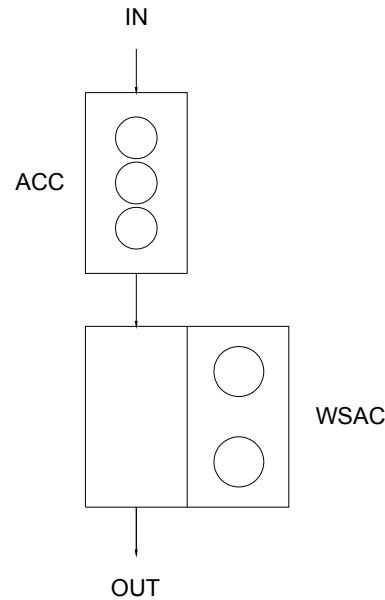
- Dry (Air Cooled) Cooling Mode for Colder Ambient Temperatures
- Evaporative (Wet) Cooling Mode for Hotter Ambient Temperatures

Wet / Dry System Options for Water Limited Power Plants

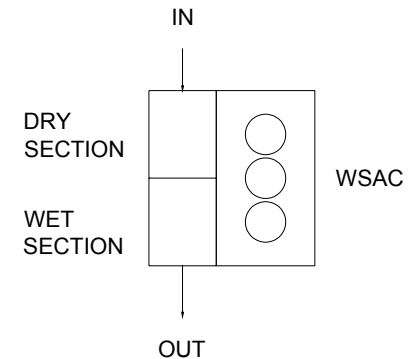
PARALLEL FLOW



SERIES FLOW



COMBINED FLOW



Advantages of WSAC for Sites with Poor Quality Makeup Water

- Spray Water on the exterior surface of the tubes, not inside Heat Exchanger
 - Ability to run Higher Cycles of Concentration
- Co-Current Flow of Water and Air
 - Even Distribution of water over the Tubes
- Unit Material Selection Based on Makeup Water Quality
 - Stainless, Titanium, Brass, Galvanized Steel

Wet / Dry Evaporative Condenser

**Dry Finned
Coil Section**

**Discharge
Plenum**

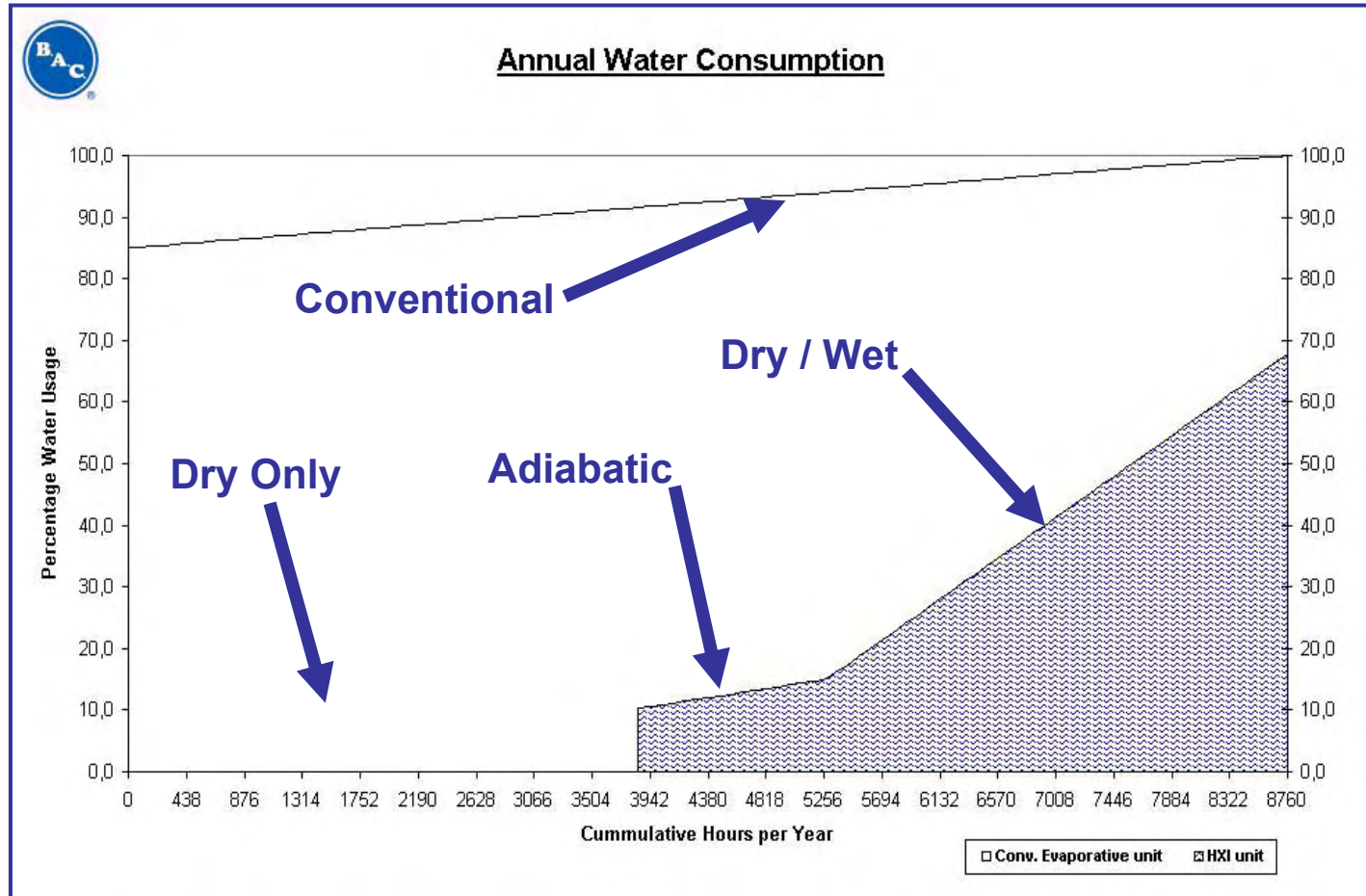
**Fan &
Evaporative
Coil Section**

Fill / Pan Section



Water Usage Graph

Percentage Water
Use



Cumulative Hours per
Year

Advantages of Wet / Dry Aux Coolers and Condensers

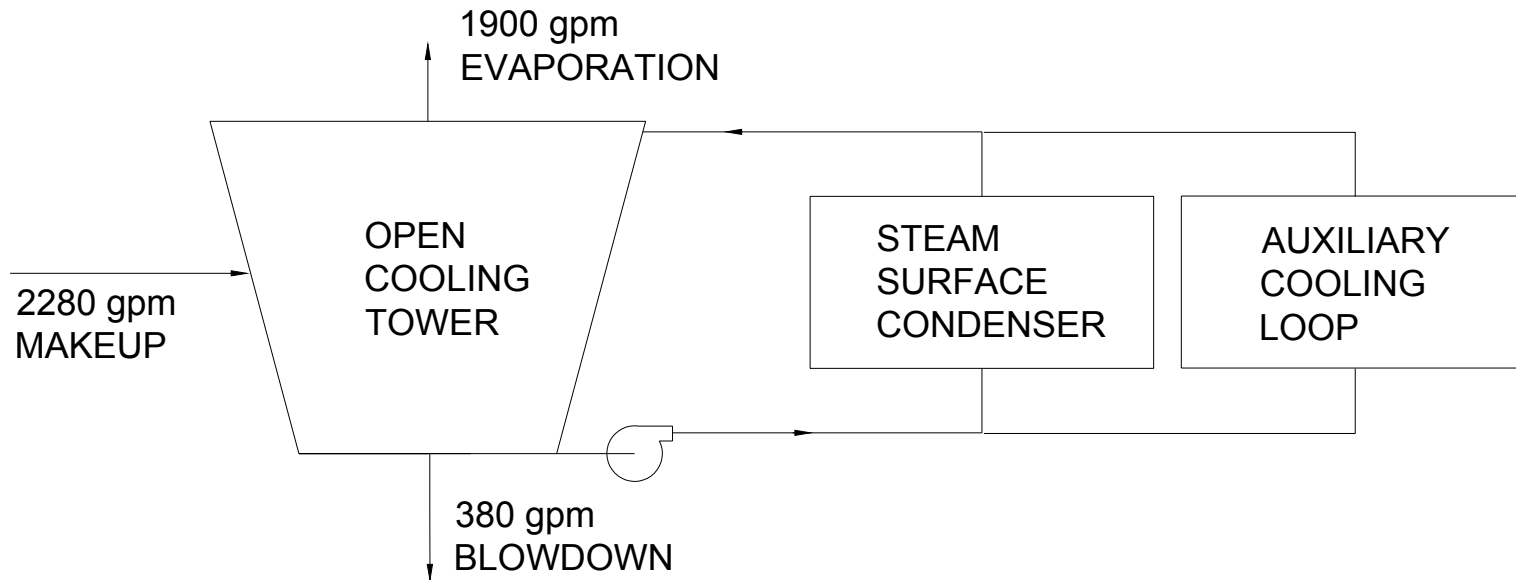
- Reasonable First Cost
- Single Source Thermal Responsibility
- Low Process Outlet/Condensing Temps
- No Plume in Cold Weather
- Low Annual Horse Power Consumption

UP TO 70% ANNUAL WATER REDUCTION

Additional Water Considerations

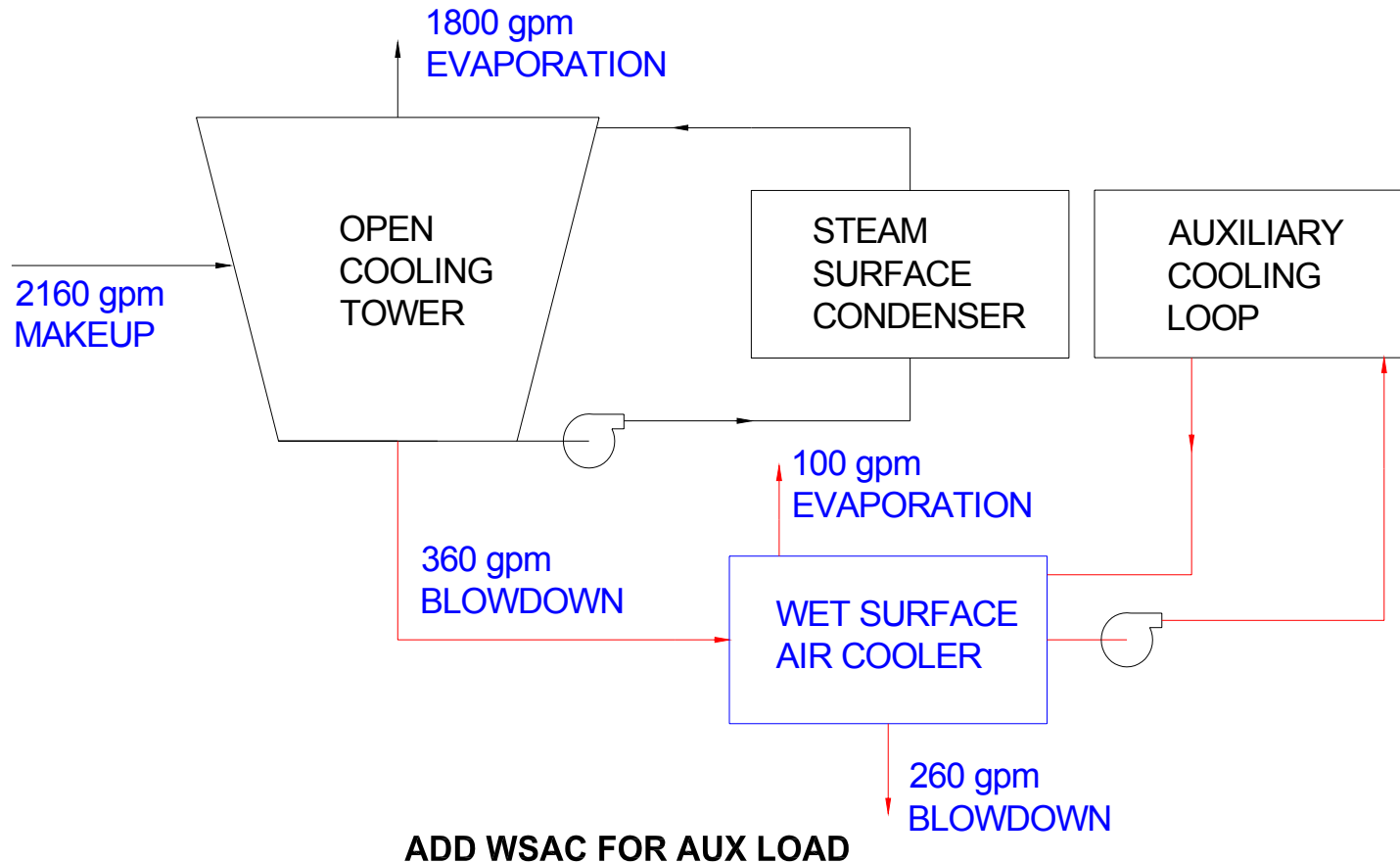
- Plume Abatement
 - Extensive Experience in Visually Sensitive Areas
- Drift
 - Drift Eliminators Easily Incorporated into Design
- PM 10
 - WSAC Meets or Exceeds PM 10 Requirements
 - Lower Total Emissions
 - Lower Discharge Height
- Zero Discharge Plants
 - WSAC Can be used as a 1st Stage Evaporator

RESOURCE CONSERVATION IN A COMBINED CYCLE POWER PLANT



EXISTING COOLING SYSTEM

RESOURCE CONSERVATION IN A COMBINED CYCLE POWER PLANT



Resource Conservation in a Combined Cycle Power Plant

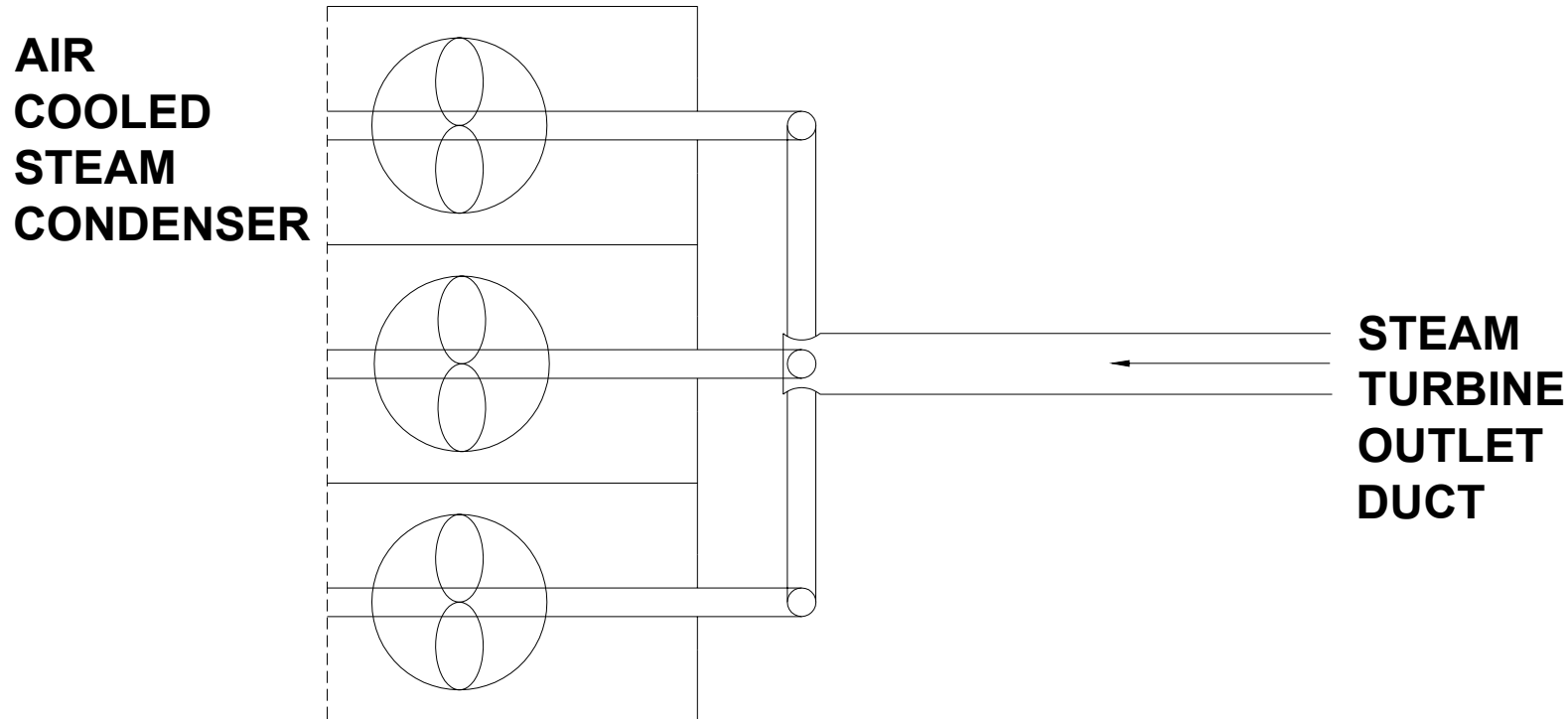
	WATER FLOW RATES	
	MAKEUP	BLOWDOWN
EXISTING SYSTEM	2280 gpm	380 gpm
MODIFIED SYSTEM	2160 gpm	260 gpm
REDUCTION	120 gpm	120 gpm
57 MILLION GALS / YEAR SAVED IN MAKEUP & BLOWDOWN		

ASSUMPTIONS:

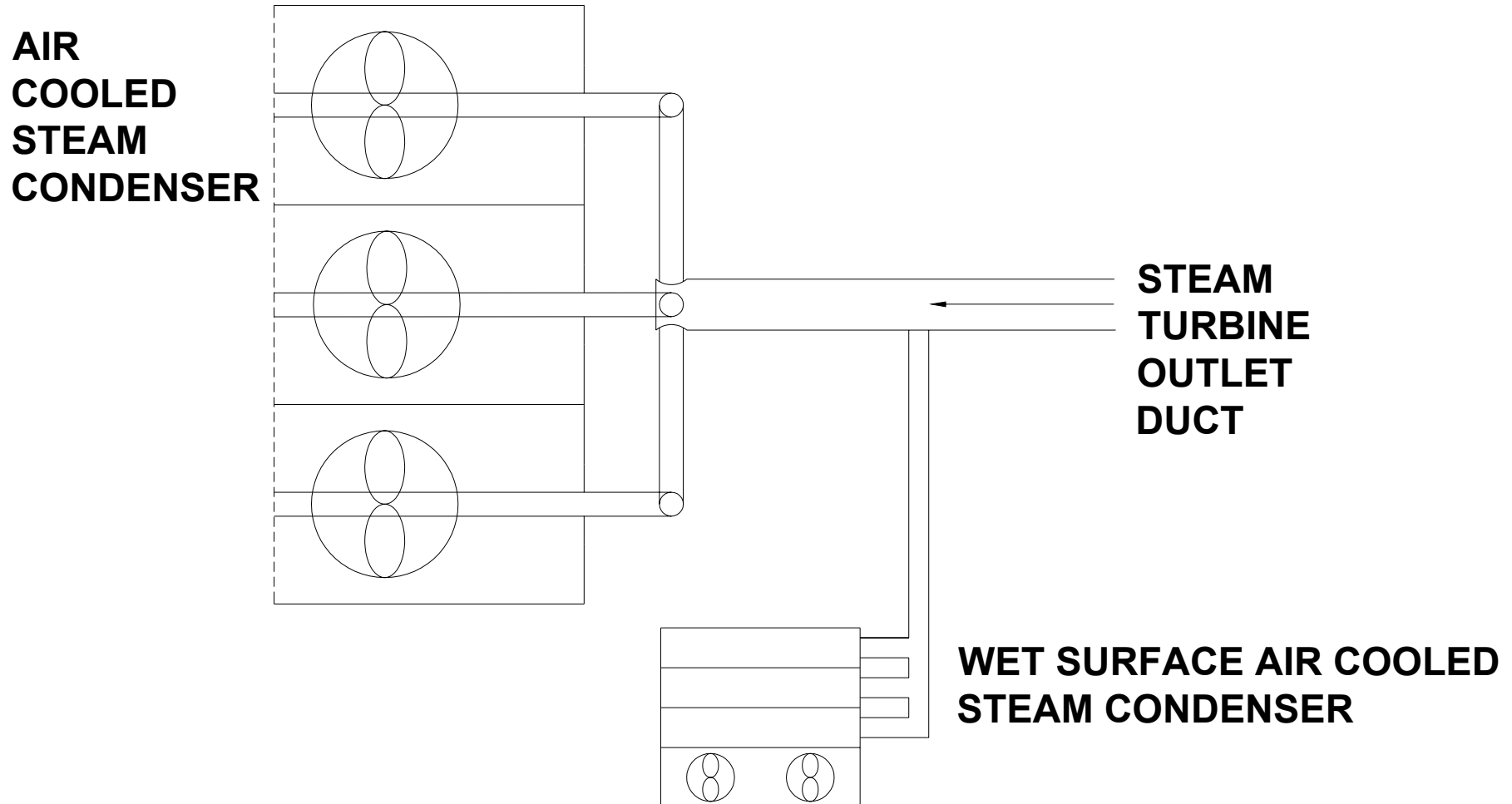
- 525 MW combined cycle plant
- 5 cycles of concentration in open tower
- 8000 hrs / yr of operation

NOTE: THIS CONCEPT CAN ALSO BE USED TO DE-BOTTLENECK STEAM CONDENSERS IN THERMALLY CHALLENGED PLANTS

DE-BOTTLENECKING A COMBINED CYCLE POWER PLANT (AIR COOLED CONDENSER)



DE-BOTTLENECKING A COMBINED CYCLE POWER PLANT (AIR COOLED CONDENSER)



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